Contribution ID: **803** Type: **Poster**

Helium Ion Energy Threshold for Helium Retention and Nano-bubble Formation in Tungsten

Friday, 21 October 2016 14:00 (4h 45m)

Tungsten has been chosen as the material for the ITER divertor and is a contender for the wall of DEMO, which will experience temperatures in excess of 1000 K. The interaction between high-flux helium plasmas with tungsten can lead to plasma-induced surface modifications. In particular helium retention in tungsten is problematic, since helium is known to form nano-scale bubbles beneath the surface, and are thought to be responsible for the formation of nano-fuzz and surface pitting [1,2].

Results from Grazing Incidence Small Angle X-Ray Scattering (GISAXS) measurements [3] performed at the Australian Synchrotron show that in tungsten exposed to pure helium plasmas in linear plasma devices, such as the MAGnetised Plasma Interaction Experiment (MAGPIE) [4], nano-sized bubbles of between 1.5 –2.5 nm diameter are formed in near-surface layers of approximately 30 nm thickness. The findings are in excellent agreement with a direct observation by transmission electron microscopy. Depth distributions were estimated by taking successive measurements across a range of x-ray incidence angles. As an example, for tungsten at 700℃, the bubble layer is observed to be 31 +/- 4 nm deep.

A helium ion energy threshold of approximately 9eV has been identified, above which helium nano-bubbles are formed and is strongly correlated with an increase in helium retention. The effects of surface temperature and plasma fluence on nano-bubble formation will also be presented.

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Paper Number

PDP-21

Country or International Organization

Australia

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Session Classification: Poster 8

Track Classification: EXD - Magnetic Confinement Experiments: Plasma–material interactions; divertors; limiters; scrape-off layer (SOL)